

Nanostructured Self-Healing Surface Films

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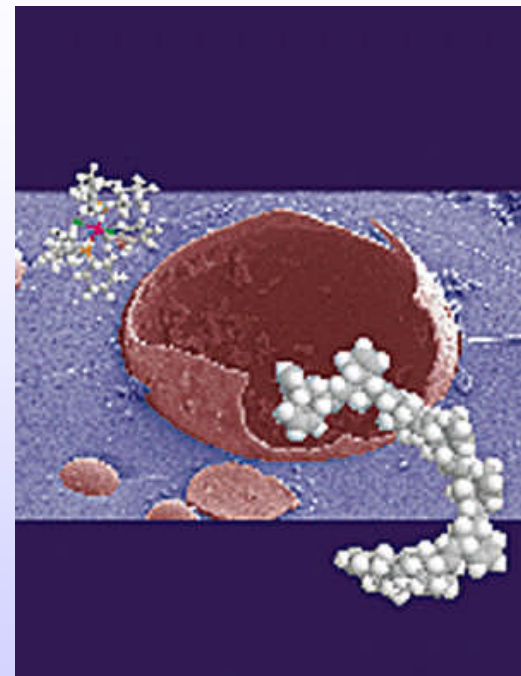


The Healing Power of Materials

- Plastics
- Metals
- Concrete
- Paint

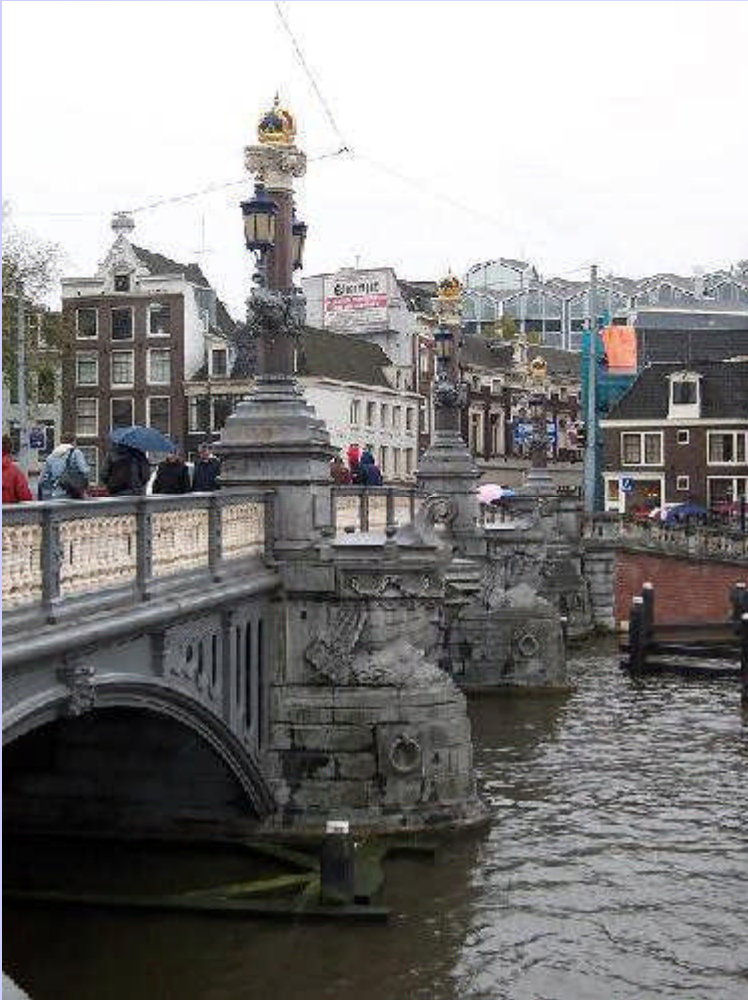


Polymers



White et al., Nature, 2001.

Concrete



Blauwe Brug, 1884.

Paint

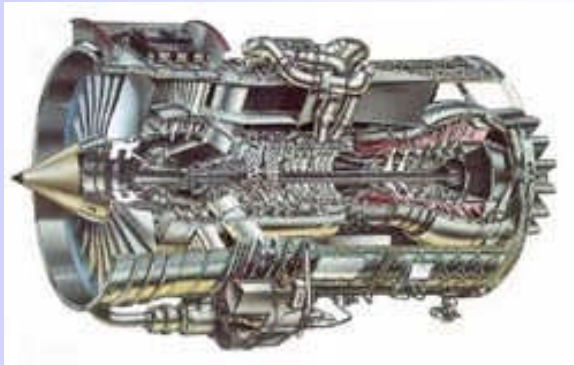


Nissan' self healing coating.

Self Healing Metals

Nature's Role:

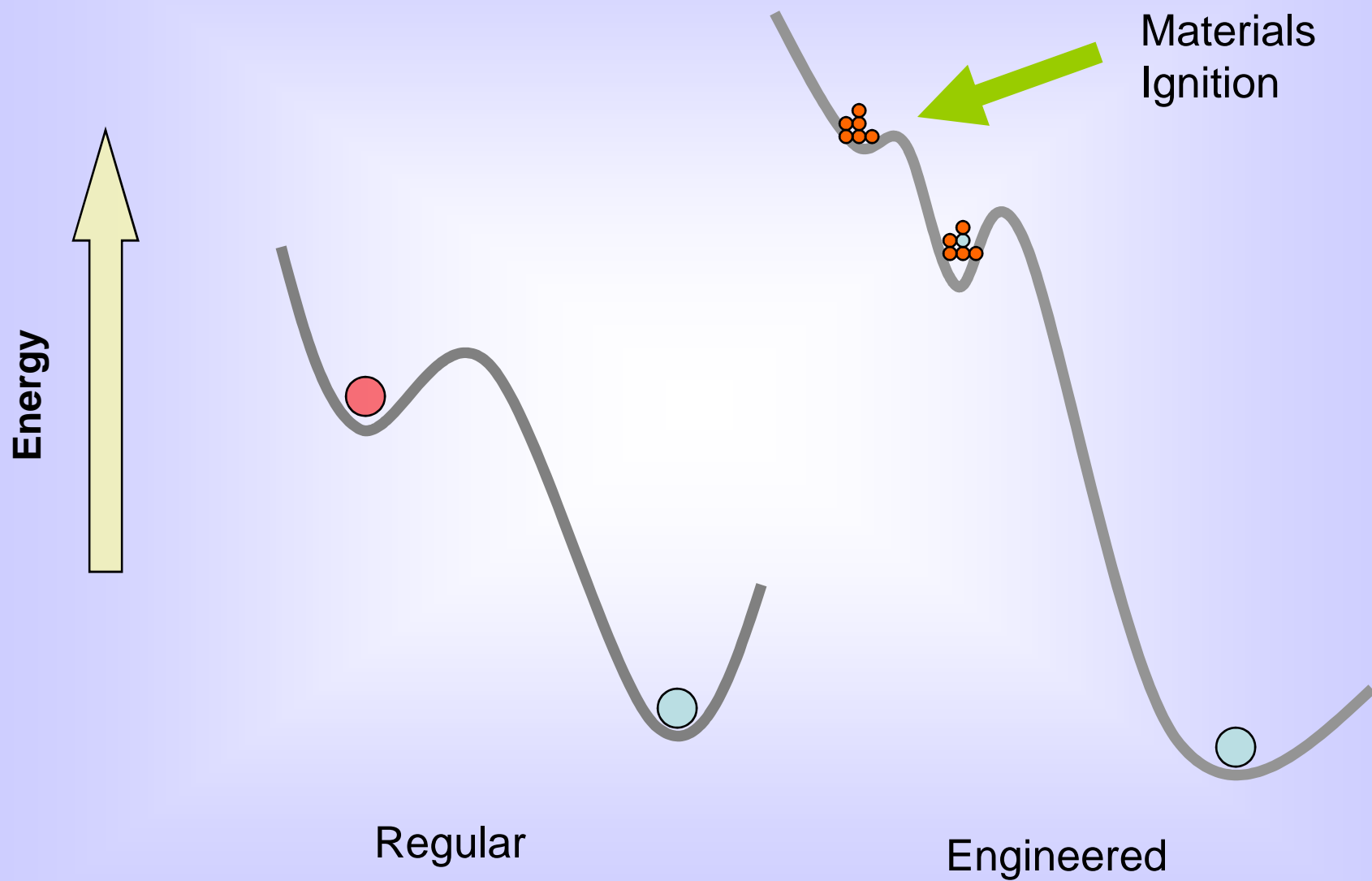
the more stable a metal is,
the longer it lasts.



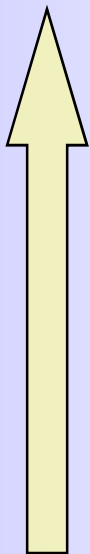
Engineered Role:

Use less stable metals to
heal cracks and fatigue.

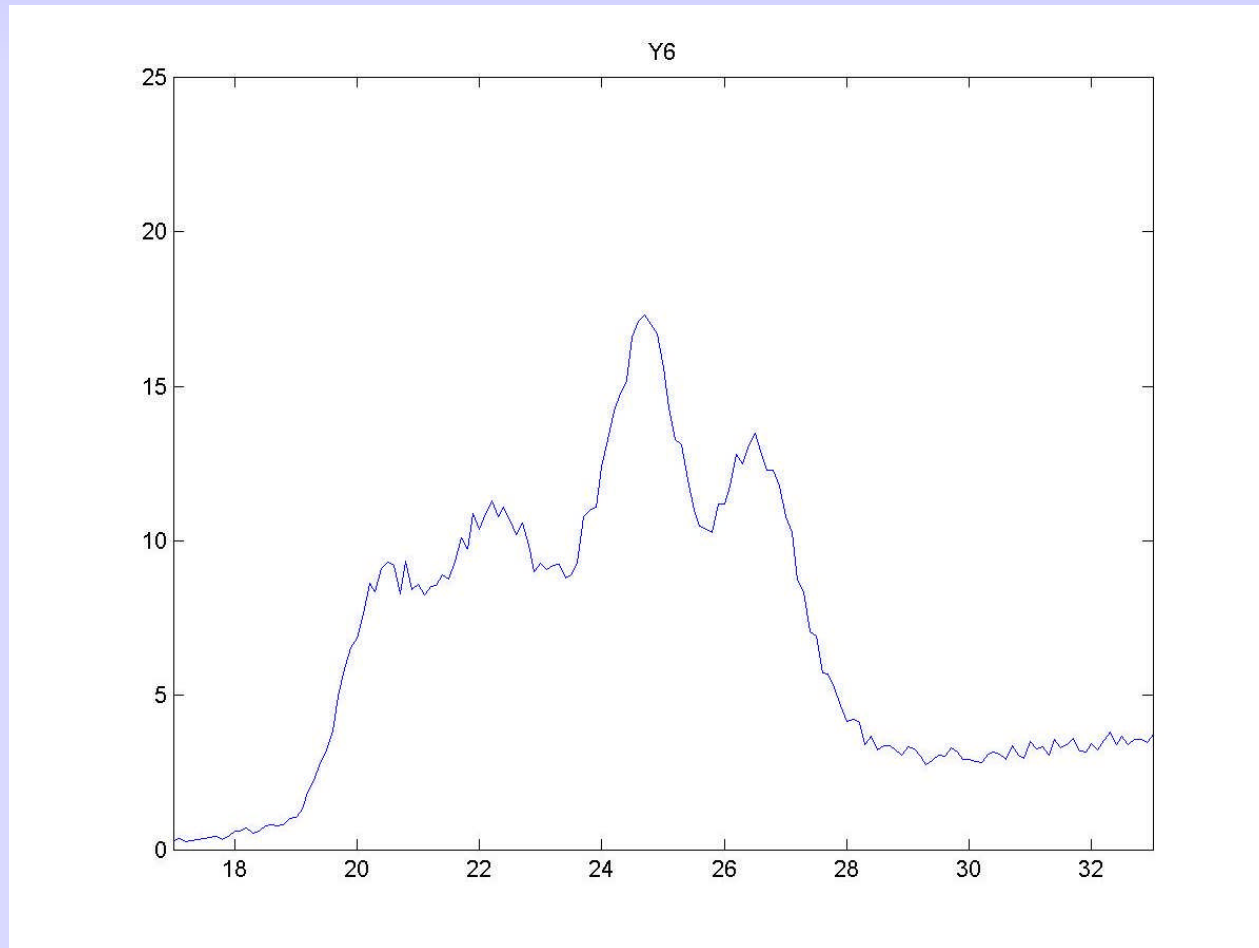
Al - Cu + Ag
CSIRO
Monash Univ.
Delft Univ. Tech.



Energy

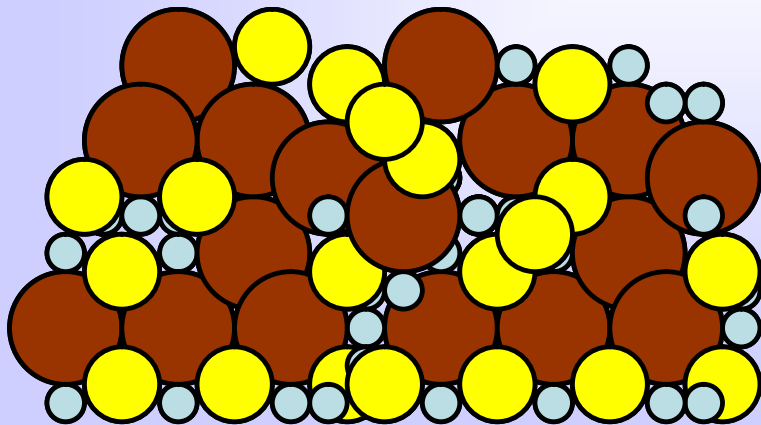
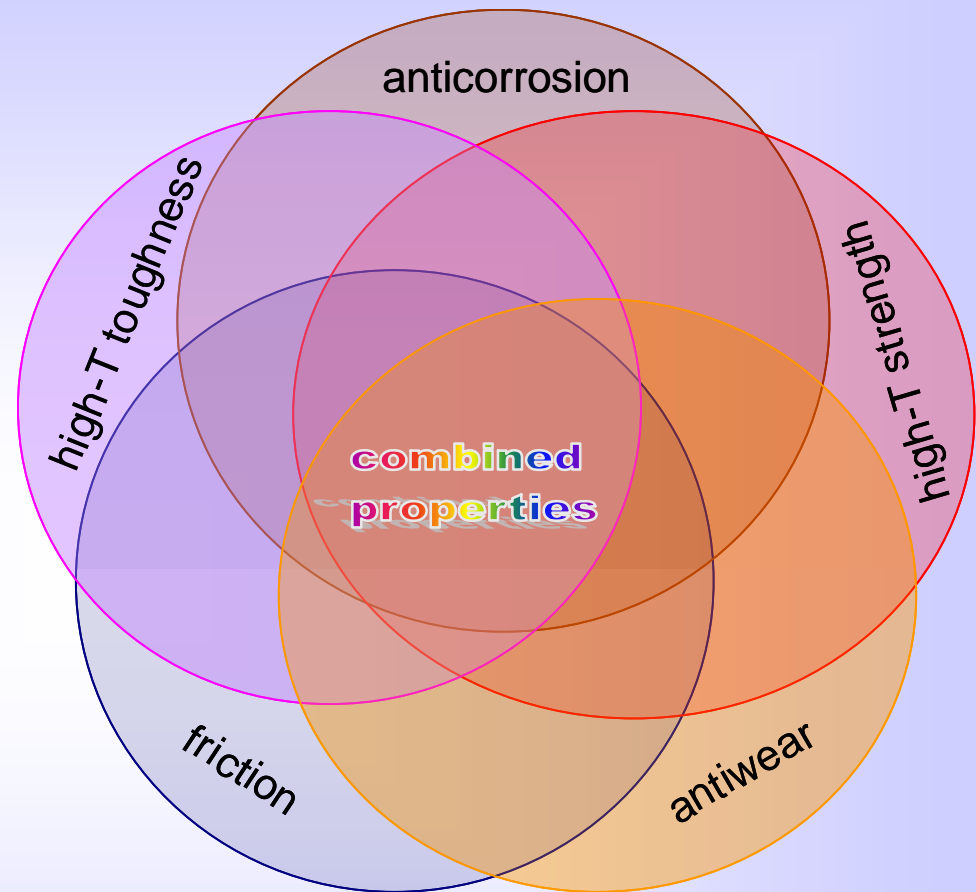


To increase the stability..

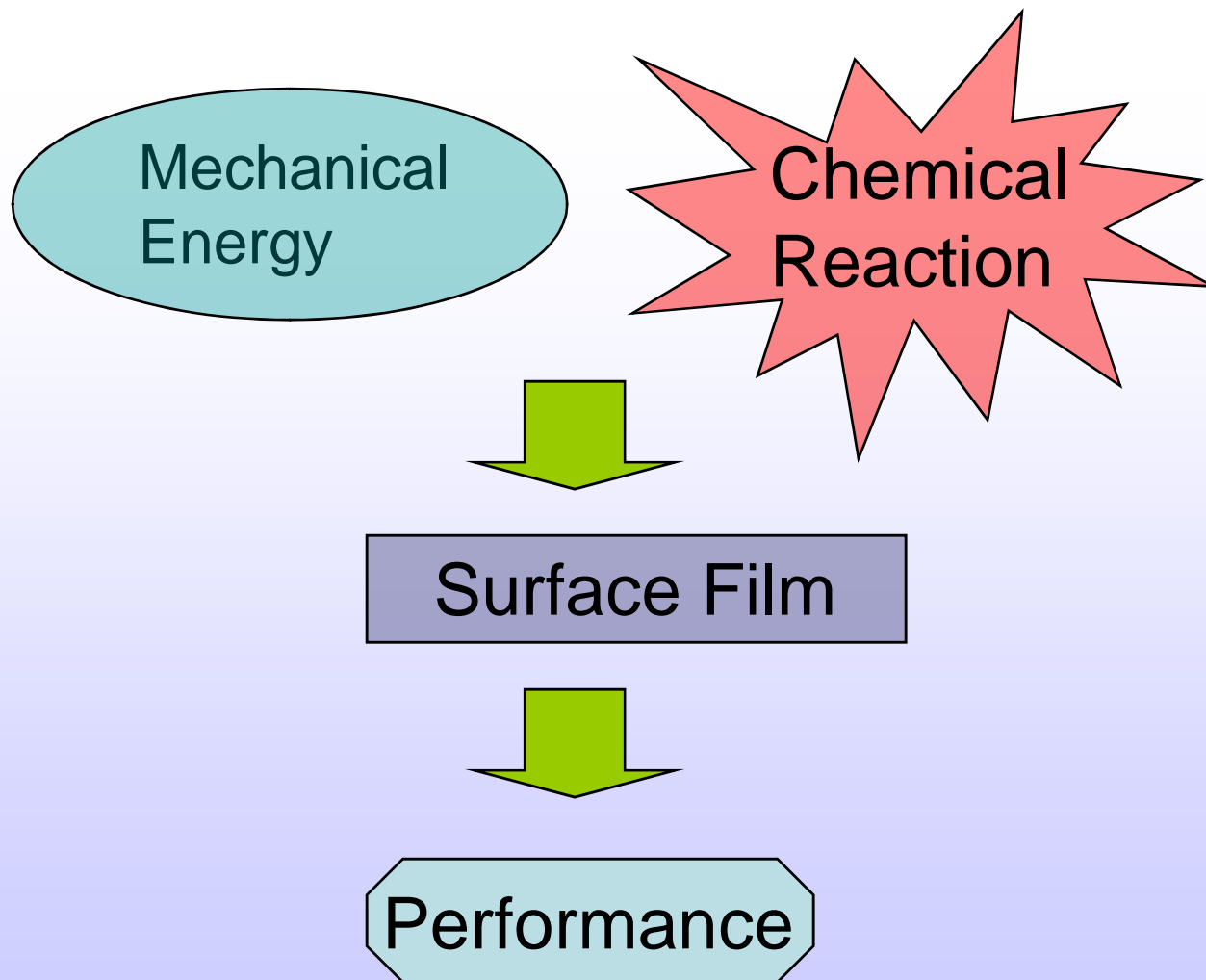


Materials are more active than we expected.

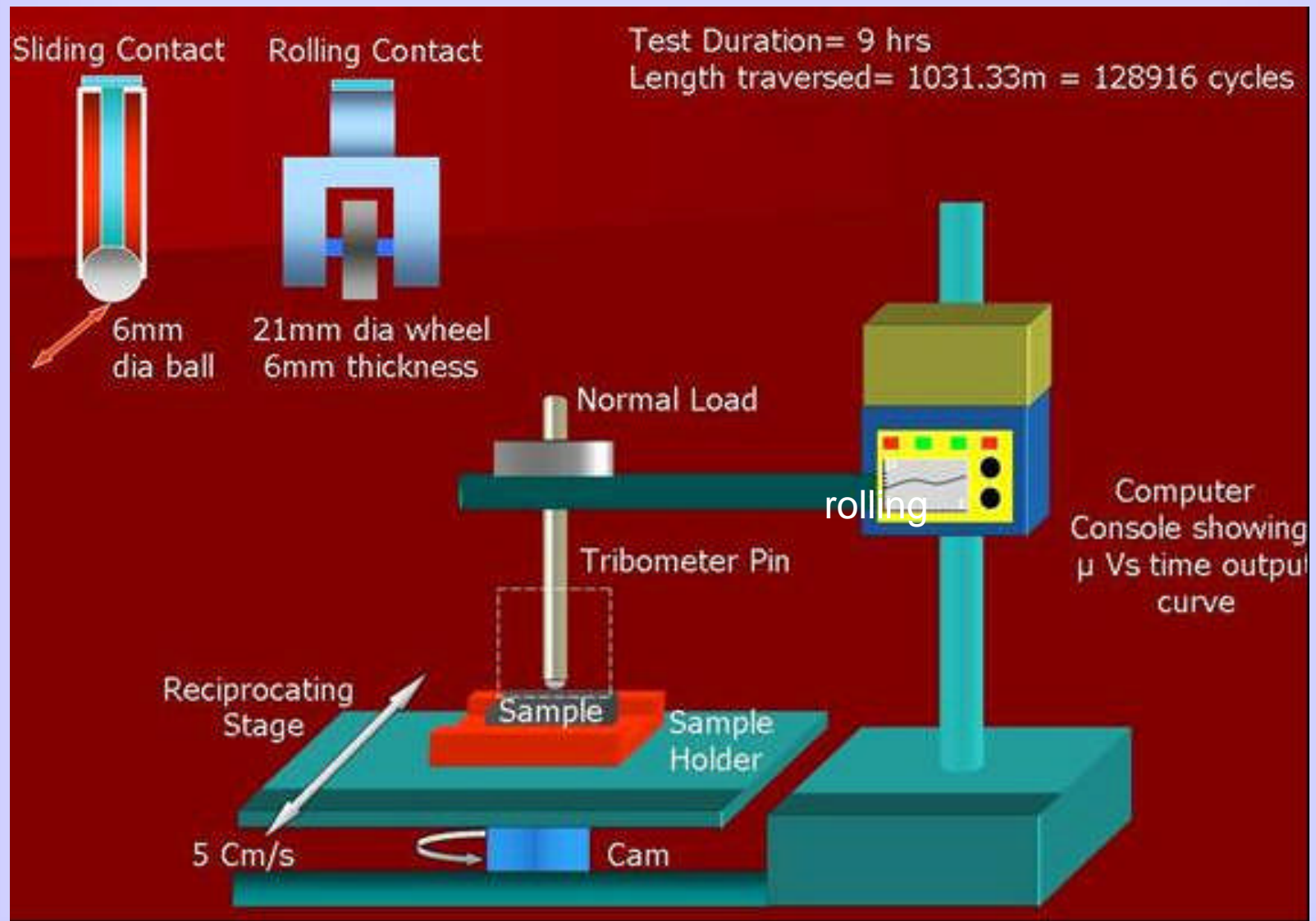
Goal



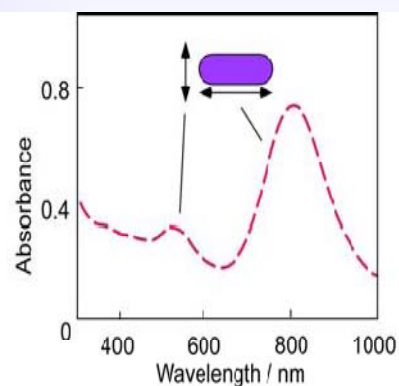
Approach



Experimental Setup



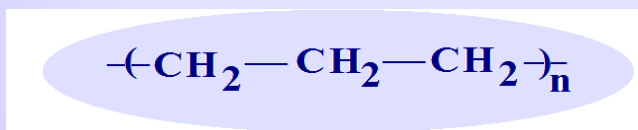
Materials:



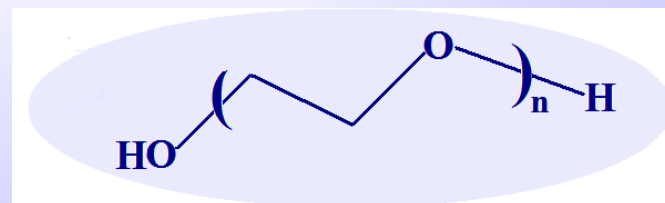
Periodic Table of the Elements

| | | | | | | | | | | | | | | | | | | | |
|---------------------|----|----|-----|----|----|----|----|----|----|-----|-----|-----|-----|----|----|----|----|----|----|
| 1A | | | | | | | | | | | | | | | | | 0 | | |
| 1 | H | | | | | | | | | | | | | | | | | 2 | He |
| 2 | Li | Be | | | | | | | | | | | | | | | 10 | Ne | |
| 3 | Na | Mg | | | | | | | | | | | | | 18 | Ar | | | |
| 4 | K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr | |
| 5 | Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe | |
| 6 | Cs | Ba | *La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn | |
| 7 | Fr | Ra | +Ac | Rf | Ha | Sg | Ns | Hs | Mt | 110 | 111 | 112 | 113 | | | | | | |
| * Lanthanide Series | | | | | | | | | | | | | | | | | | | |
| 58 | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | | | | | |
| + Actinide Series | | | | | | | | | | | | | | | | | | | |
| 90 | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr | | | | | |

Vehicles:

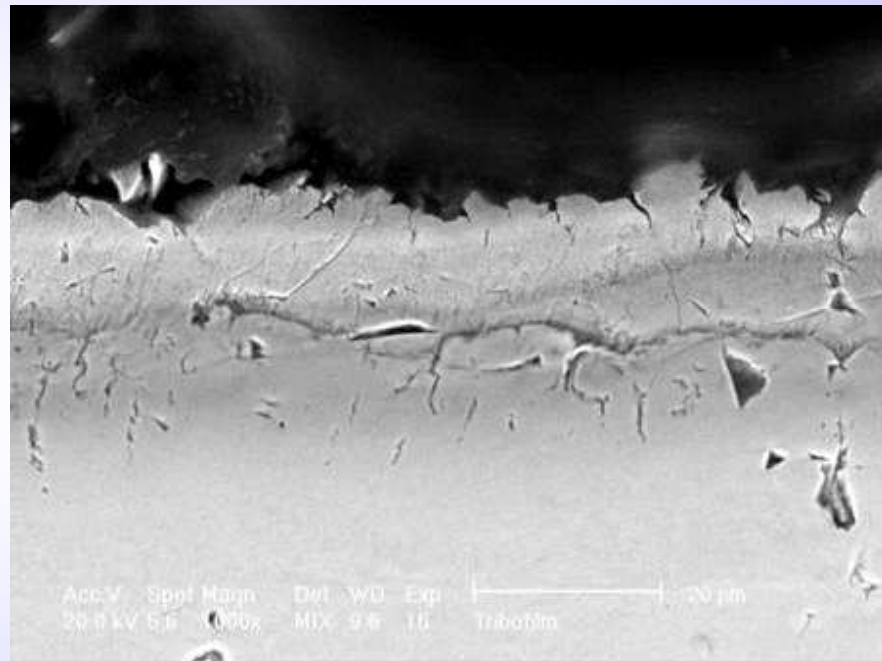
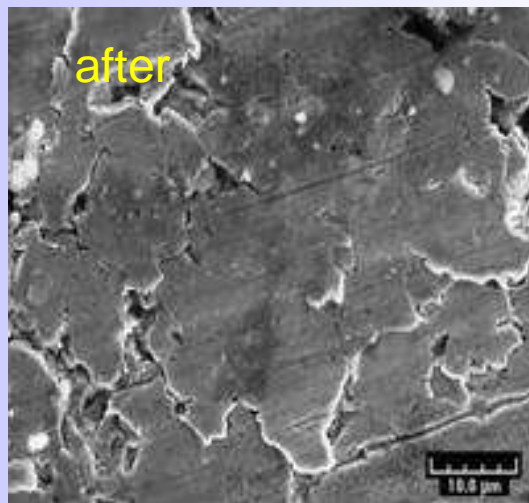
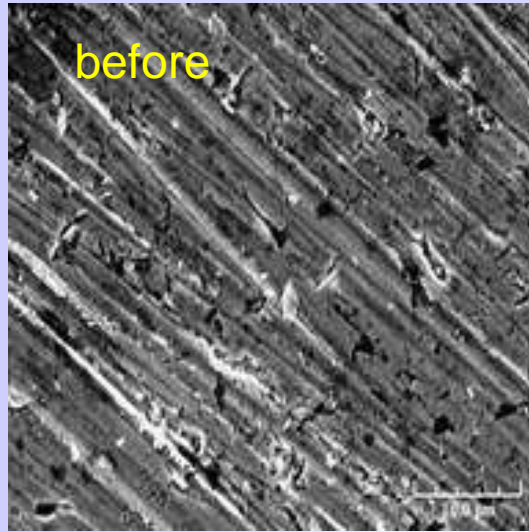


Mineral Oil Chemical Structure



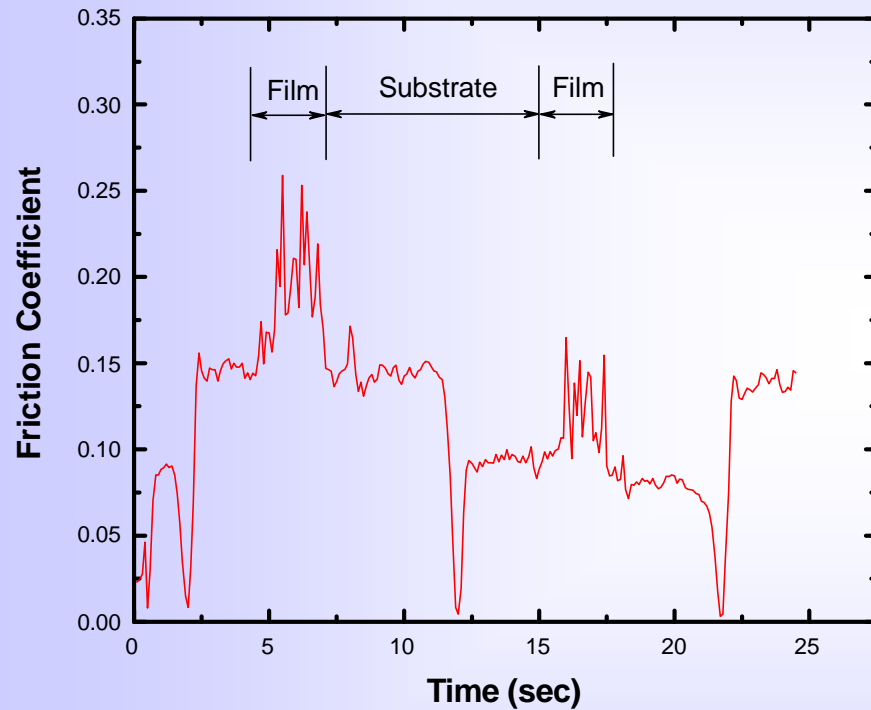
PEG Chemical Structure

Track Surface

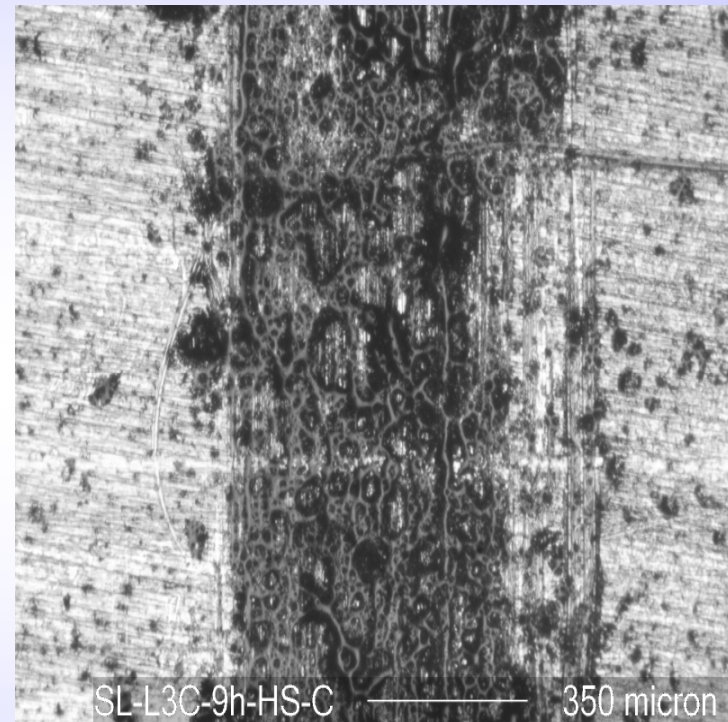


Cross Section

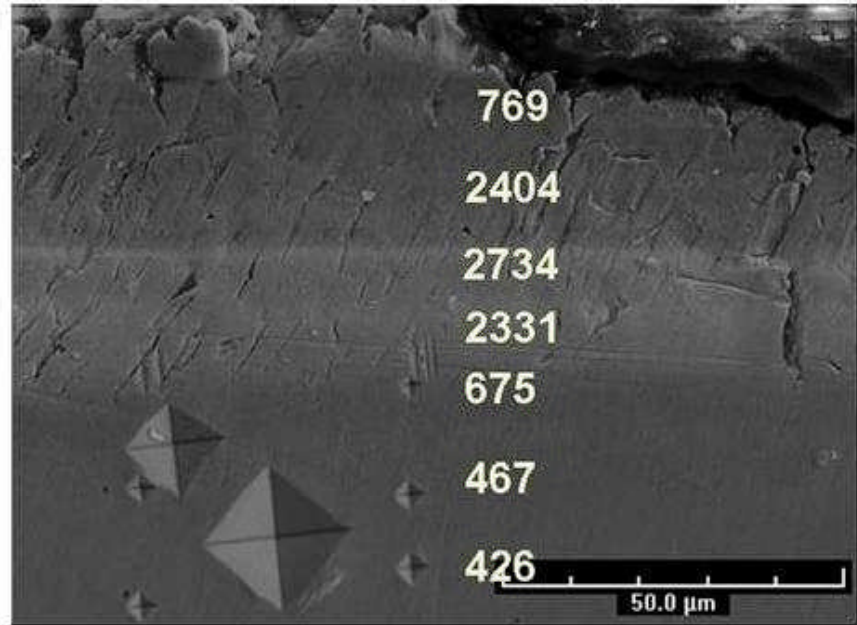
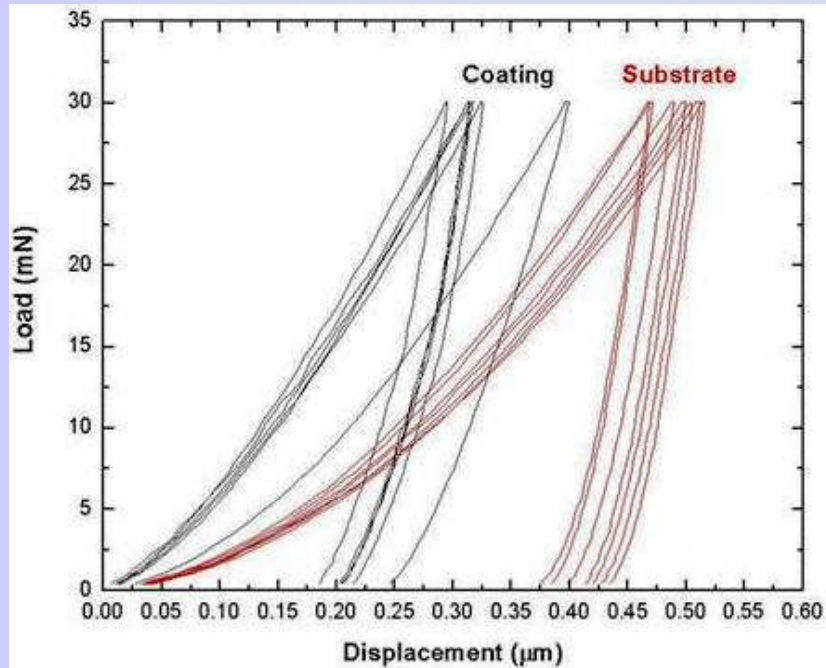
The film is wear resistant



Scratch tests

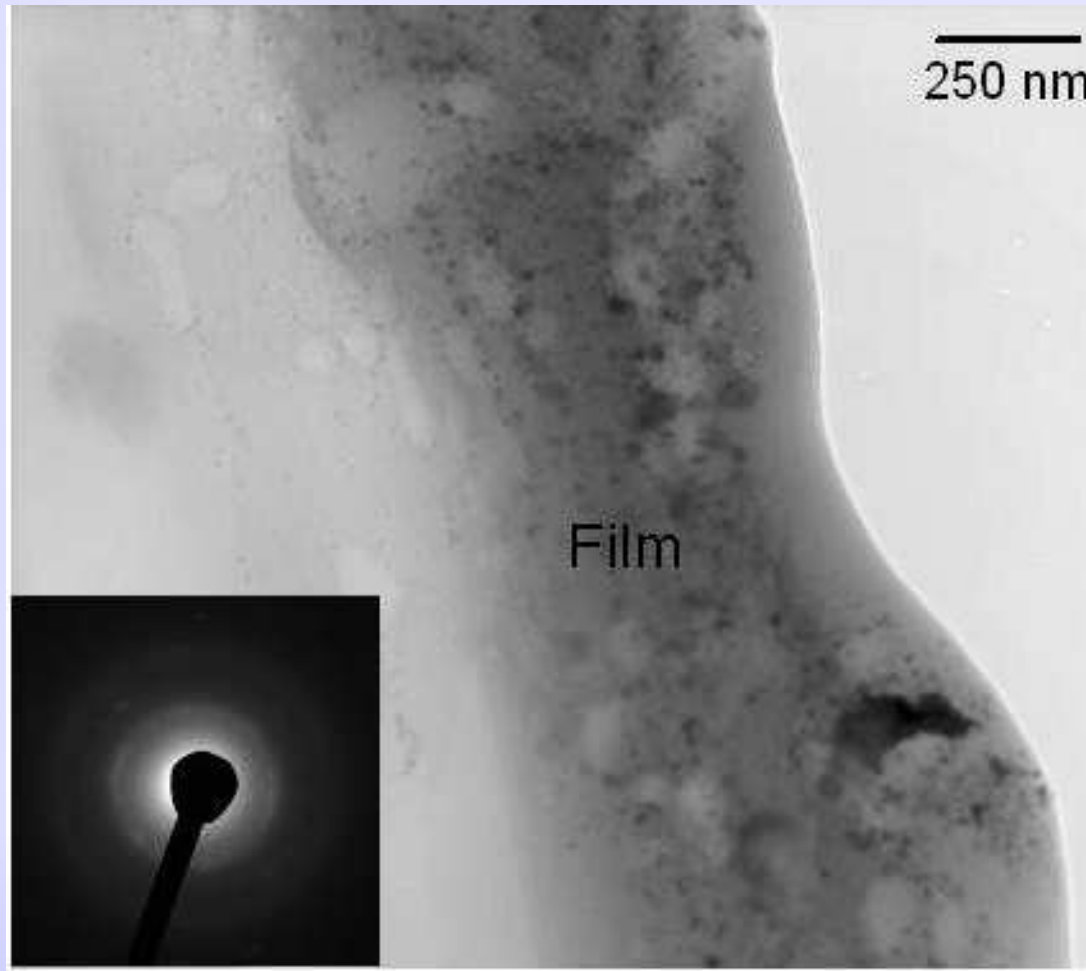


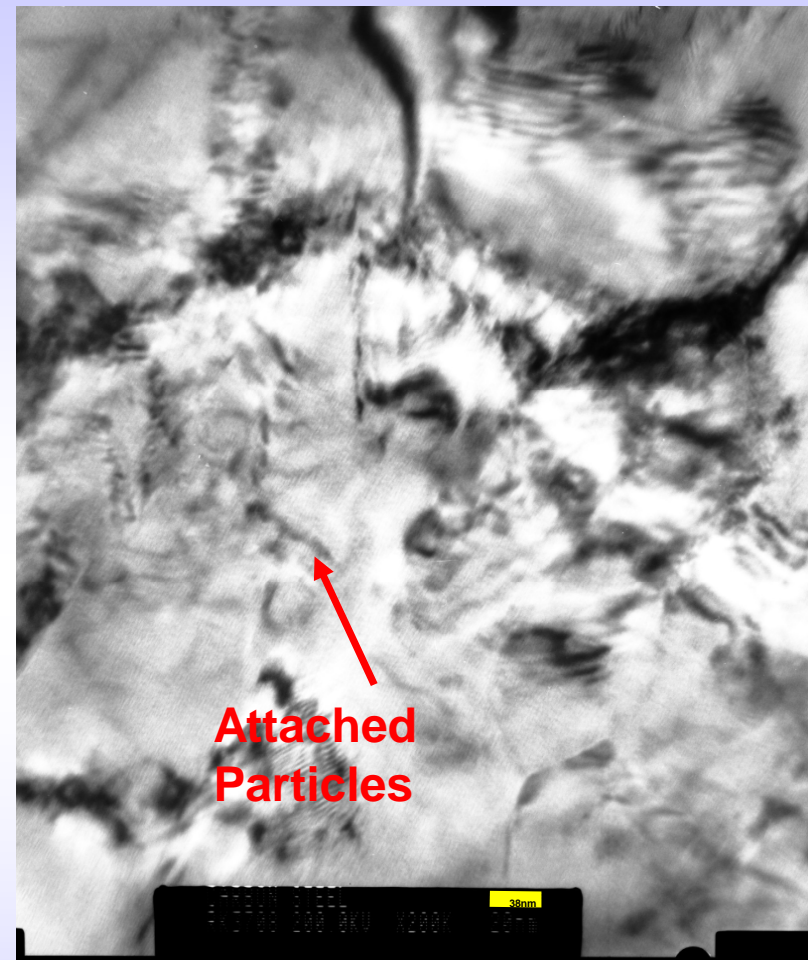
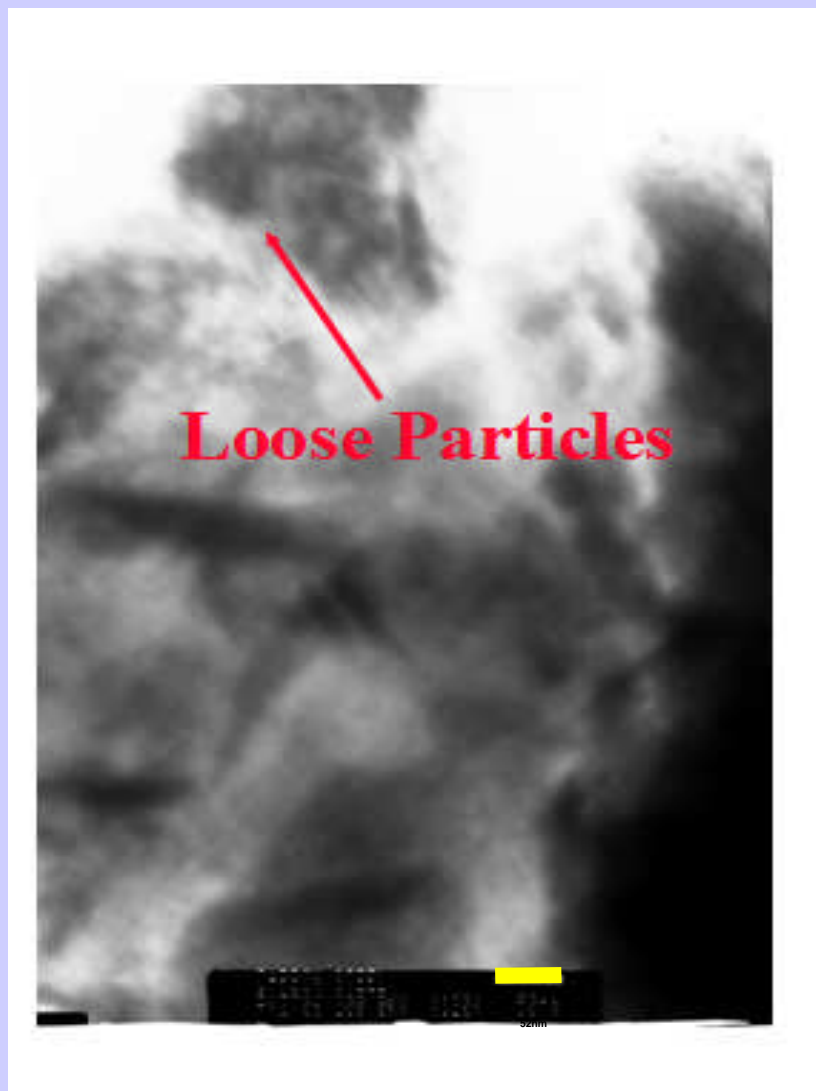
Wear tests



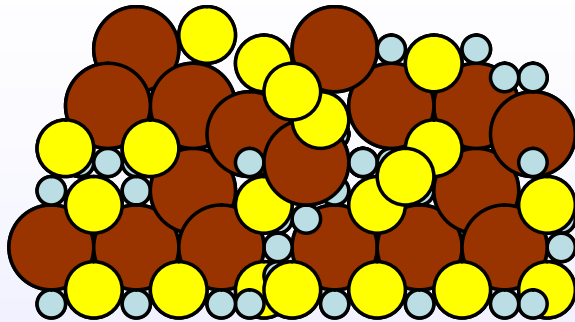
Microhardness of the film is more than five times of that of the substrate

The film is made of nanostructured/amorphous layer





Summary

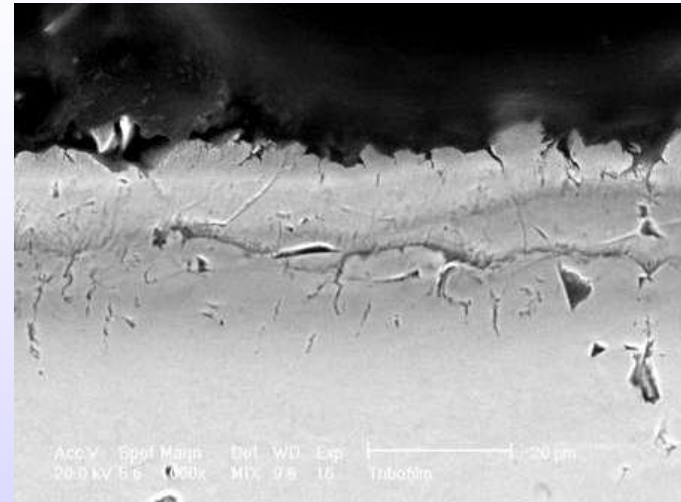


Periodic Table of the Elements

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1 H | | | | | | | | | | | | | | | | | 10 Ne | | | | | | | | | | | | | | | | | | |
| 2 Li | 3 Be | | | | | | | | | | | | | | | | | 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 4 K | 5 Ca | 6 Sc | 7 Ti | 8 V | 9 Cr | 10 Mn | 11 Fe | 12 Co | 13 Ni | 14 Cu | 15 Zn | 16 Ga | 17 Ge | 18 As | 19 Se | 20 Br | 21 Kr | | | | | | | | | | | | | | | | | | |
| 6 Rb | 7 Sr | 8 Y | 9 Zr | 10 Nb | 11 Mo | 12 Tc | 13 Ru | 14 Rh | 15 Pd | 16 Ag | 17 Cd | 18 In | 19 Sn | 20 Sb | 21 Te | 22 I | 23 Xe | | | | | | | | | | | | | | | | | | |
| 8 Cs | 9 Ba | 10 La | 11 Hf | 12 Ta | 13 W | 14 Re | 15 Os | 16 Ir | 17 Pt | 18 Au | 19 Hg | 20 Tl | 21 Pb | 22 Bi | 23 Po | 24 At | 25 Rn | | | | | | | | | | | | | | | | | | |
| 7 Fr | 8 Ra | 9 Ac | 10 Th | 11 Pa | 12 U | 13 Np | 14 Pu | 15 Am | 16 Cm | 17 Bk | 18 Cf | 19 Es | 20 Fm | 21 Md | 22 No | 23 Lr | | | | | | | | | | | | | | | | | | | |

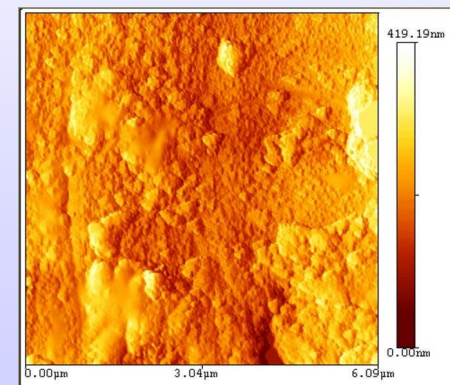
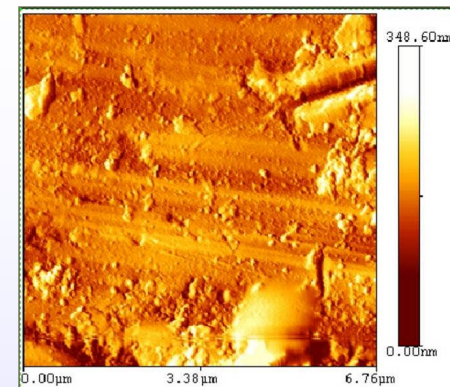
* Lanthanide Series

+ Actinide Series



Summary

- Mechano-chemical process to form a surface film.
- Mechanical energy is highly controllable.
- The film can lubricate, self-repair, maintain, and extend materials' service life significantly.



AFM Micrographs.